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ABSTRACT

Contradictory previous research results showing that (1) language knowledge does not decrease with age; and (2) age differences exist in semantic strategies for memory recall provide the impetus for a study of semantic priming in young adults (mean age = 20) and older adults (mean age = 70) by providing target and prime words with six different types of categorical relationships. Accuracy and response time for the primed trials were measured. Results show no evidence for age differences in structural semantic memory even when a wide variety of semantic relationships between target and prime word are considered and the response latencies for lexical decisions are analyzed over multiple trial blocks. While differing types of semantic relationships produce differing degrees of response time facilitation, there is no age difference in which semantic relationship produces most facilitation. (MSE)

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Semantic Priming Revisited: In Search of Structural Age Change in Semantic Knowledge

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Salthouse (1982) reviewed research literature pertaining to adult age change in the structure of semantic memory and concluded that there was no evidence for any structural change throughout adulthood. One's knowledge of language--meanings and referents, rules for manipulating words--apparently undergoes no modification from the time that one acquires skilled language (somewhere in one's adolescence) throughout fifty or more years of experience with one's language in a variety of contextual settings. Salthouse bases his conclusions on data from paradigms (Bransford & Franks procedure, priming of lexical decisions, Stroop, release from PI) designed to assess interrelationships between various word meanings and ideas. Any older adult performance deficit can be attributed, according to Salthouse, to a general rather than language-specific slowing of cognitive activation that accompanies aging. However, Salthouse found that there is usually a main age effect attributable to response slowing, there is no found age by treatment interactions.

Salthouse's conclusions are based on an exhaustive review of research on semantic activation, yet the great amount of continued work in this field suggests researchers find his conclusions difficult to accept. They do so because considerable research has also established the existence of measurable differences by age in semantic strategies used during memory recall. Thus, researchers continue to attempt to account for the deficits in semantic strategies by attempts to demonstrate the existence of structural change. However, because no one has examined specific types of semantic relationships directly in their work, two important problems have not been explored.

First, there is little agreement as to what type of "structural change in semantic memory" would be expected. Several authors have suggested that a broadening of semantics categories might occur (Mergler & Goldstein, 1983) which could effect speed of response and accuracy (as defined by young adult standards)

of lexical decisions. It is unclear if the older adult should have more exemplars within a category or more overlap between categories or more layers to a hierarchical categorical system; but the implication is that there is a greater amount of detailed semantic information that must be stored in an organized fashion with increasing age. While much of language use might be considered rote rehearsal of the existing semantic structures, it is inconceivable that some refinement of knowledge--with complex nuances of meaning--does not occur during adult life span.

This implicit assumption seems contrary to Eysenck's (1974) suggestion that elderly don't elaborate on verbal information "in depth" and that they cannot utilize semantic coding strategies to improve memory. However, this assumption could explain how it is that elderly are slower than young adults during a category recognition task (Eysenck, 1975) since they may have more exemplars within category to scan.

These authors (Mergler & Goldstein, 1933) argue that one must decide what type of structure change to look for instead of using manipulation like word frequency (Bowles & Poon, 1981) within category exemplars (Howard, McAndrews, & Lasaga, 1981; Mueller, Kausler, Faherty, & Oliveri, 1980), or descriptive property associates (Howard, et al., 1981). To test this way of defining and examining semantic change, the following experiment specifically isolated different kinds of semantic relationships that exist between words, had pilot subjects generate examples of these word relationships, and constructed target-prime word combinations from these subject-generated examples (see Schvaneveldt, Durso, & Mukherji, [1982] for an experiment with young adults that considers such qualitative types of differences in semantic relationships). This isolation of different relations, some of which are categorical, can measure the difference by age in categorical responses in semantic structures that researchers have

found in semantic strategies to aid memory recall (Sanders, Murphy, Schmitt & Walsh, 1980; Hultsch, 1971).

A second problem with the existing literature is the assumption that structure change would be evident in all paradigms if it exists. However, change in speed of lexical access for certain types of comparisons may not be reflected over multiple trial blocks of lexical decisions. It is possible that repeated activation of target words by different types of primes could cause a reduction in the primed facilitation and may do so more quickly for older subjects with the hypothesized global activation (Mergler & Goldstein, 1983; Mergler & Zandi, in press) than younger subjects. The following experiment also attempts to explore this problem by giving each subject seven trial blocks and meaning differences in response over time.

Method

Subjects

Twenty-six subjects comprising two different age groups participated in this experiment. Younger subjects included 13 volunteer undergraduate students enrolled in General Psychology at the University of Oklahoma (mean age = 20, s.d. = 2.01). Older subjects included 13 volunteer citizens who were at least 60 years of age and resided near the OU campus (mean age = 70, s.d. = 6.33). All subjects were administered the WAIS vocabulary subtest. Mean raw scores on the WAIS were 43.31 (s.d. = 8.4) for younger subjects and 48.18 (s.d. = 8.28) for older subjects; this difference was not significant $t(22) = 1.43$.

Apparatus

Visual stimuli were presented on a projection screen (1.03 m X .64 m) using a Gerbrands model G1175 3-field projection tachistoscope. The duration and sequence of slide presentation were controlled using a Gerbrands 300 series

6-channel timer interfaced with a Gerbrands model G1159 tachistoscope logic interface. A Hunter model 131C digital timer connected to a Hunter model 142 digital display was used to measure reaction time responses.

Stimulus Materials

Visual stimuli consisted of pairs of letter strings, each letter string forming either a word or a nonword. A total of 140 words and 107 nonwords were used in the experiment (see Appendix A). All words were concrete nouns. Key stimulus pairs of a target word and one of six types of prime words were constructed such that the prime had a certain categorical relationship to the target word. Six different types of relationships were defined as follows: 1. semantic relationship, in which the target and prime words were semantically related but were not associates (e.g., $\overset{T}{\text{chair}} \leftarrow \overset{P}{\text{saddle}}$); 2. subordinate relationship, in which the prime word was a subcategory of the target word (e.g., $\overset{T}{\text{chair}} \leftarrow \overset{P}{\text{rocker}}$); 3. supraordinate relationship, in which the target word was a subcategory of the prime word (e.g., $\overset{T}{\text{chair}} \leftarrow \overset{P}{\text{furniture}}$); 4. strong associative relationship, in which there was a high degree of associative strength between the target and prime words (e.g., $\overset{T}{\text{chair}} \leftarrow \overset{P}{\text{table}}$); 5. relatively weak associative relationship, in which there was a lower degree of associative strength between the target and prime words (e.g., $\overset{T}{\text{chair}} \leftarrow \overset{P}{\text{sit}}$); and 6. no relationship, in which the target and prime words were unrelated (e.g., $\overset{T}{\text{chair}} \leftarrow \overset{P}{\text{bird}}$). For each of 20 target words, the word most frequently reported for each of the six definitions of relationships for those target words were selected from a word-norming study conducted prior to the experiment that utilized students enrolled in general psychology. All nonwords (formed from valid words with two random letter replacements) were also tested for associative strength; any nonword that elicited a specific word association in 10% of the norming subjects

was eliminated. The target words and primes used in the study appear in Appendix A, organized according to the six categories, while nonwords are listed in Appendix B. Median word length was five letters, ranging from three to 11 letters. Nonwords had a median word length of five letters and ranged from four to six letters.

Seven blocks of the 20 stimulus pairs were formed such that each target word appeared once in each block paired with one of its six primes or a nonword. All six types of target-prime relationships occurred three times within each block. Each block also included eight word-nonword pairs and eight nonword-nonword pairs. Each block of 36 letter strings contained 18 positive trials (both letter strings were valid words) and 18 negative trials (two target-nonword, eight nonword-nonword, and eight word-nonword). The top letter string for each pair was randomly assigned. Order of the letter strings within each block was randomized, and order of the seven blocks was randomized. Slides of the letter strings were constructed such that the two letter strings were black capital letters on white ground centered one above the other. When projected on a screen 1.7 m from the subject, the letter strings subtended 20° horizontally and 8° vertically and each letter was approximately 75 mm in height and 60 mm in width. A warning signal slide was composed of four stars in a square marking the center of each line where upon the letter strings would appear.

Design and Procedure

The independent variables were age (younger and older subjects), type of relationship between the target-prime word pairs, and order of trial blocks. The dependent measures to assess the priming effect were accuracy and RT on target-prime pairs beyond that exhibited on target-unrelated word pairs. Each subject received all seven blocks of trials during one session, order

counterbalanced across subjects. A session lasted approximately 40 minutes, with one-minute rest periods given between blocks.

Subjects were run individually. After completing the preliminary tests subjects were informed about the nature of the experimental task. If both letter strings in the target slide were words, the subject was instructed to depress one of two momentary push buttons and to depress the other if either (or both) of the letter strings were nonwords. The right and left push buttons were depressed with the index finger of the right and left hand, respectively. Half of the subjects in each age group were randomly assigned to indicate positive responses with the right hand, while the other subjects in each age group indicated positive responses with the left hand. Subjects were encouraged to respond as quickly and accurately as possible. Prior to receiving the first block of trials, the subject was given eight practice trials, in random sequence. No feedback regarding performance was given at any time during the experiment.

Results

Accuracy

The mean percentage of errors made in each condition by young and old subjects is displayed at the bottom of Figure 1. A mixed design analysis of variance was computed for the six types of primed "yes" responses to the lexical decision for age, block order, and type of primed relationship. There was a main effect of prime type, $F(5, 1056) = 10.24$, $p < .001$; no other effects were significant. An unprimed "yes" trial with two unrelated words yielded more errors than any type of primed trial, among which types there were no significant differences in accuracy.

Response Times

For each participant, the mean correct response time on each type of primed trials within each block was calculated (see Figure 1). A mixed design analysis

of variance was computed with age as a between subjects factor and trial block and type of primed relationship as within subjects factors. There were main effects for type of primed relationship, $F(5, 1056) = 18.32$, $p < .001$; for age, $F(1, 1056) = 240.79$, $p < .001$; and for block order, $F(6, 1056) = 12.18$, $p < .001$. Response was slower on trial block 1 than trial block 2 and trial block 2 was slower than any of the remaining trial blocks 3 through 7. The older adults were 166 msec slower than the young adults. All subjects were faster with a primed stimulus pair than the unrelated pair. Among the types of primes, target-supraordinate relationships produced the most response time facilitation (150 msec). The associative within category, associative outside of category, and target-subordinate produced statistically the least response time facilitation (122 msec, 118 msec, and 108 msec, respectively) and the non-associative semantically related prime produced least facilitation (50 msec) but was faster than two unrelated words.

Discussion

There is no evidence for any age differences in structural semantic memory even when, as in this experiment, a wide variety of semantic relationships between target and prime word are considered and the response latencies for lexical decisions is analyzed over multiple trial blocks. Response times become quicker over trial blocks but equally so for both young and older adults. The prime effect remains the same over all trial blocks. While differing types of semantic relationships produce differing degrees of response time facilitation, there is no age difference in which semantic relationship produces most facilitation.

These data confirm previous studies (Howard et al., 1981; Bowles & Poon, 1981) that examined lexical decisions in young and older adults. However, there are methodolgical differences in these studies that require further

comment before one concludes that slowing of cognitive activation (Salthouse, 1982) causes any age differences in response time. Table 1 compares the original Meyer and Schvaneveldt (1971) article with three developmental priming studies. First, all but Bowles and Poon (1981) used a 50:50 ratio of yes and no responses to the lexical decision. Response strategy may be dependent on likelihood of two words appearing on a given trial; this occurred 67% of the time within this study and may account for higher error rates in their word-nonword trials than evidence in the other two developmental studies. It may also account for the greater amount of priming facilitation evidence in this study.

In the original Meyer and Schvaneveldt experiment, trials with two related words produced the quickest response, followed by nonword-nonword trials, two unrelated word trials and word-nonword trials the slowest. This Mergler et al. data conforms to this hierarchy, while data from the other two developmental studies has any yes response, primed or not, leading to quicker responding than any no response. The exact instructions emphasizing speed and accuracy that the subject hears may cause this shift in hierarchy; the nature of the nonwords may also effect this hierarchy. However, all these studies produced nonwords in essentially identical manners.

Finally the difference between the young and old adult's priming effect (mean RT for unrelated words minus mean RT for related words) varies from 10 msec more facilitation for older adults in Mergler et al., to 72 msec more facilitation for older adults in Howart et al. to 108 msec more facilitation for older adults in Bowles et al. A cursory scan (Table 1) of the young and old adult subject characteristics (educational level and vocabulary scores) cannot account for this difference. Instrumentation differences across laboratories clearly affects the overall baseline response time possible in any trial, but the absolute

differences in amount of facilitation in trials when two words are related is interesting. Both Howard et al. and Bowles et al. studies found more absolute facilitation for older adults than their younger adults but the Mergler et al. data does not. If the prime effect is stated as a percentage of the response time for two unrelated words trials, then the age differences in amount of relative facilitation disappear for all studies. To measure percentages assumes the prime effect is not a part or stage in decision-making taking more or less time, but rather that it is a facilitation of the entire act of apprehension. Here again is evidence that whatever the structure of semantic activation is, it is not divisible in the ways that strategies of memory retrieval can be divided.

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Appendix A

Words Used in the Experiment Organized According to Category

Target Word	Semantic Relation	Subordinate Relation	Supraordinate Relation	Strong Associative	Weak Associative	Unrelated Word
GREEN	ENVY	OLIVE	COLOR	RED	FROG	FLESH
ROOF	UMBRELLA	SHINGLE	HOUSE	TOP	CHIMNEY	TRUCK
MAN	PREDATOR	BOY	HUMAN	WOMAN	STRONG	ACRE
CLOCK	CALENDAR	ALARM CLOCK	TIME	SUNDIAL	HOUR	MOTION
LENGTH	SCALE	YARD	MEASURE	WIDTH	DISTANCE	CLAY
WATER	EARTH	ICE	LIQUID	JUICE	DRINK	DESK
EYE	CAMERA	PUPIL	SENSES	NOSE	SEE	RABBIT
STAR	LAMP	SUN	GALAXY	PLANET	SKY	PIANO
GASOLINE	ELECTRICITY	UNLEADED	FUEL	OIL	CAR	ALLIGATOR
MILK	FRUIT	CREAM	DAIRY	CHEESE	COW	RESULT
KING	PRESIDENT	PRINCESS	RULER	QUEEN	CROWN	SMASH
FLOWER	RAINBOW	ROSE	PLANT	WEED	PRETTY	CABINET
CASH	PROPERTY	DOLLAR	MONEY	CHECK	BANK	SCREAM
FEAR	REASON	SCARED	EMOTION	ANGER	NIGHT	ENEMY
CHICKEN	COWARD	HEN	BIRD	DUCK	FRIED	VESSEL
SUITCASE	SACK	BRIEFCASE	BAGGAGE	LUGGAGE	TRAVEL	GOLF
PAGE	SCREEN	WORD	BOOK	PAPER	LETTER	HAMMER
FISH	SURF	BASS	FOOD	LOBSTER	SWIM	STRIPE
DAY	WORK	NOON	TIME	NIGHT	SUNSHINE	OVERLAP
CHAIR	SADDLE	ROCKER	FURNITURE	TABLE	SIT	BIRD

Appendix A

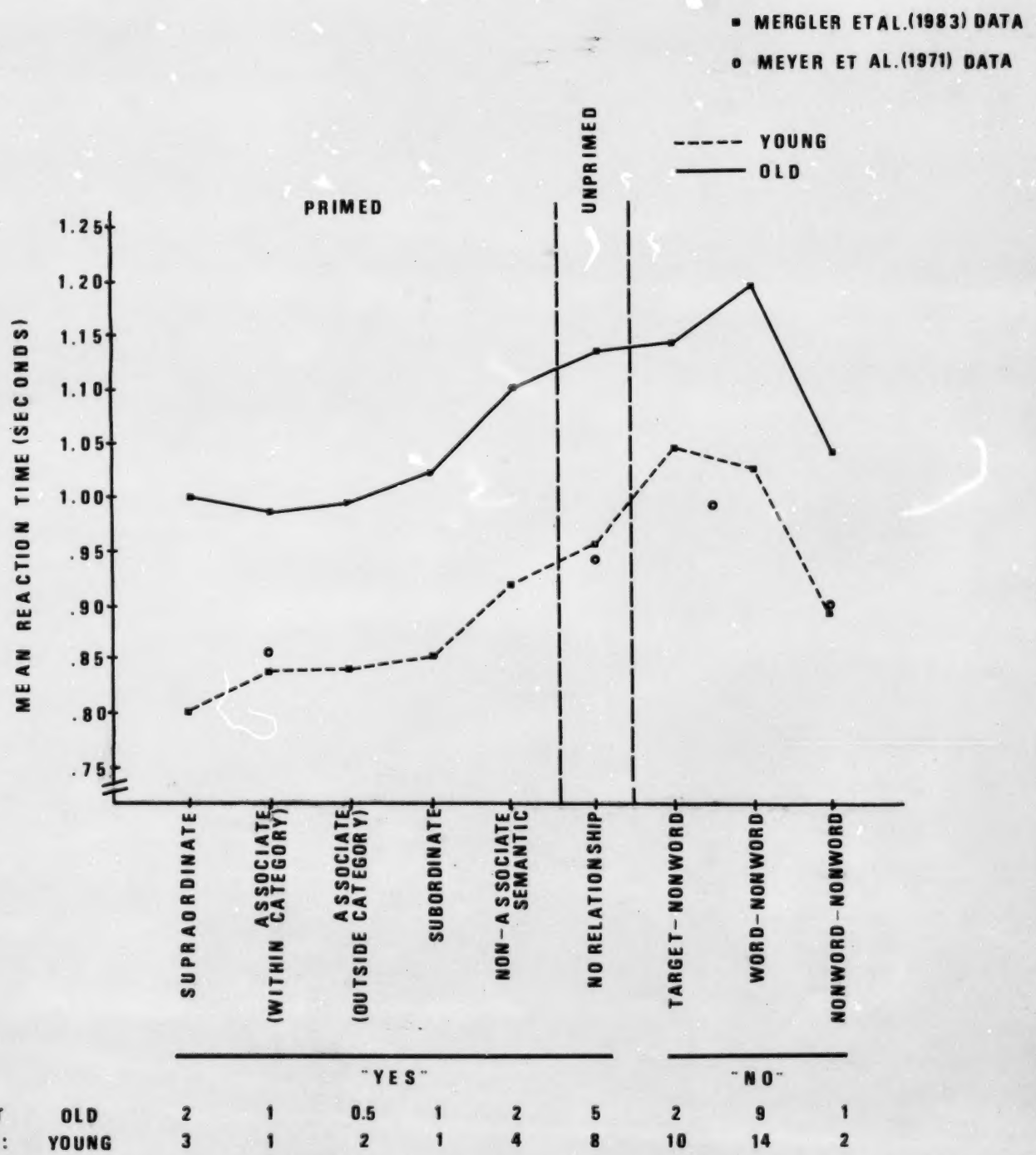
List of Nonwords Used in Experiment

BENES	GADATE	WAON	SHEK
TACH	INRASE	PERP	MERON
IMRON	CRUEH	OFNS	STKO
PTIN	ECGHE	PHOGY	PASANT
OBEYER	MBLE	SEIC	HEREST
AGGO	INTERT	PAMID	COFY
TESG	ETATE	CLMES	ASBLE
BYAINE	BRYN	SILOE	PYER
BENEN	ADTL	PITTO	SERITY
FUTL	CAION	PECT	GAETE
HWET	GELM	INTRT	BERH
FANAW	VAUR	ADET	MOFA
IADER	SILOW	FUOR	FME
FAIY	DOTORY	CODTE	COSE
GATATE	SNEBL	LUBYN	DGHO
PILSY	MELM	PAON	VONI
SYGO	CATEO	POJO	ITEAR
CTISH	RIBN	LITISH	VATON
SOTRF	AMAL	MATIO	HREST
GLBE	PANOR	ADISH	GENOWB
DOSTN	BIAGO	POLET	GATTR
TIXOM	GBER	KILISH	SENTOW
KODDI	FANTI	VISOM	HITOSH
MOSTO	DIGTO	OBYER	LUBAY
SERIT	PYGO	KIRO	FOME
EBRCE	FITROV	KOUT	HOLEX
JANTEY			

Table 1

	Meyer & Schvaneveldt 1971	Howard, McAndrews & Lasaga, 1981		Bowles & Poon, 1981		Merg1er, Zandi & Charleston, 1983	
	young	young	old	young	old	young	old
C.A.		28	70	21	74	20	70
ed. level		15.3	15.2	13	13		
WAIS vocab.					53	43	48
% of all trials that were "no" responses	50%	50%		33%		50%	
non-word-non-word trials							
error %	2.6%	4.2%	3.3%	4.0%	6.0%	14%	9%
RT msec	884	1132	1504	1437	2008	880	1040
word-nonword or nonword-word trials							
error	17.7%	9.4%	6.9%	15.5%	14.5%	9.2%	5%
RT	996	1204	1646	1607	2265	1030	1175
2 unrelated words trials							
error	8.7%	2.0%	5.8%	12.0%	11.0%	8.0%	5.0%
RT	940	1029	1504	1369	1826	950	1130
2 related words trials							
error	6.3%	2.4%	5.0%	1.0%	2.0%	2.0%	1.0%
RT	855	960	1363	1055	1404	850	1020
subtraction method prime effect	2.4% more accurate	0.4% less accurate	0.8% more accurate	11.0% more accurate	9.0% more accurate	6.0% more accurate	4.0% more accurate
	85 msec quicker	69 msec quicker (6.7%)	141 msec quicker (9.4%)	314 msec quicker (22.9%)	422 msec quicker (23.1%)	100 msec quicker (10.5%)	110 msec quicker (9.7%)
addition method prime effect (with yes trials) main age diff?	--	accuracy-no RT old slower		accuracy-no RT old slower		accuracy-no RT old slower	
age x semantic relationship	--	accuracy-no RT-no		no no		no no	
age x trial block		-- --		-- --		accuracy-no RT-no	
age x semantic relationship x trial block						accuracy-no RT-no	

Figure 1. Differences in speed and accuracy of lexical decisions due to age and type of primed semantic relationship.



PERCENT ERRORS:	OLD	2	1	0.5	1	2	5	2	9	1
	YOUNG	3	1	2	1	4	8	10	14	2